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**Hornby et al.**

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(54) **MUFFLER SHIELD AND MUFFLER ASSEMBLY EMPLOYING THE SAME**

(71) Applicant: **FORD GLOBAL TECHNOLOGIES, LLC**, Dearborn, MI (US)

(72) Inventors: **Steven Allen Hornby**, Ypsilanti, MI (US); **Erich James Nowka**, Ann Arbor, MI (US); **Kerry Timothy Havener**, Canton, MI (US)

(73) Assignee: **FORD GLOBAL TECHNOLOGIES, LLC**, Dearborn, MI (US)

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***F01N 13/00*** (2010.01)

(52) **U.S. Cl.**
CPC ..... ***F01N 13/00*** (2013.01); *F01N 2260/00* (2013.01); *F01N 2260/18* (2013.01); *F01N 2260/20* (2013.01); *F01N 2510/00* (2013.01)

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CPC .... F01N 2260/20; F01N 13/08; F01N 13/14; F01N 13/141
USPC ..... 181/282, 283
See application file for complete search history.

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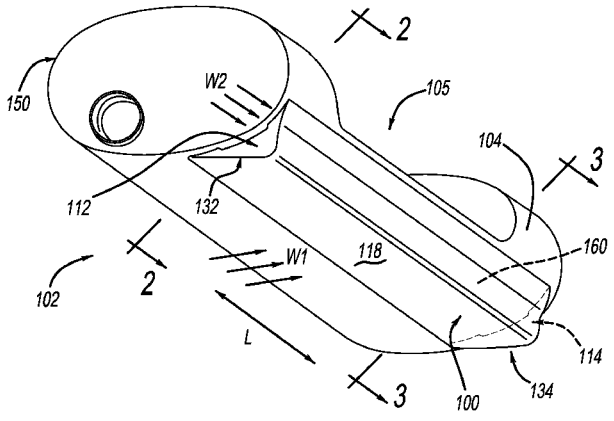
*Primary Examiner* — Jeremy Luks

(74) *Attorney, Agent, or Firm* — Gregory P. Brown; Law Firm of Dr. Junqi Hang, PLC

(57) **ABSTRACT**

In one or more embodiments, a muffler shield includes a shield body extending in a longitudinal direction and defining a middle portion positioned between first and second side portions along a transverse direction, a cross-section of the middle portion and at least one of the first and second side portions respectively defining a middle profile and a side profile shorter than the middle profile.

**8 Claims, 4 Drawing Sheets**



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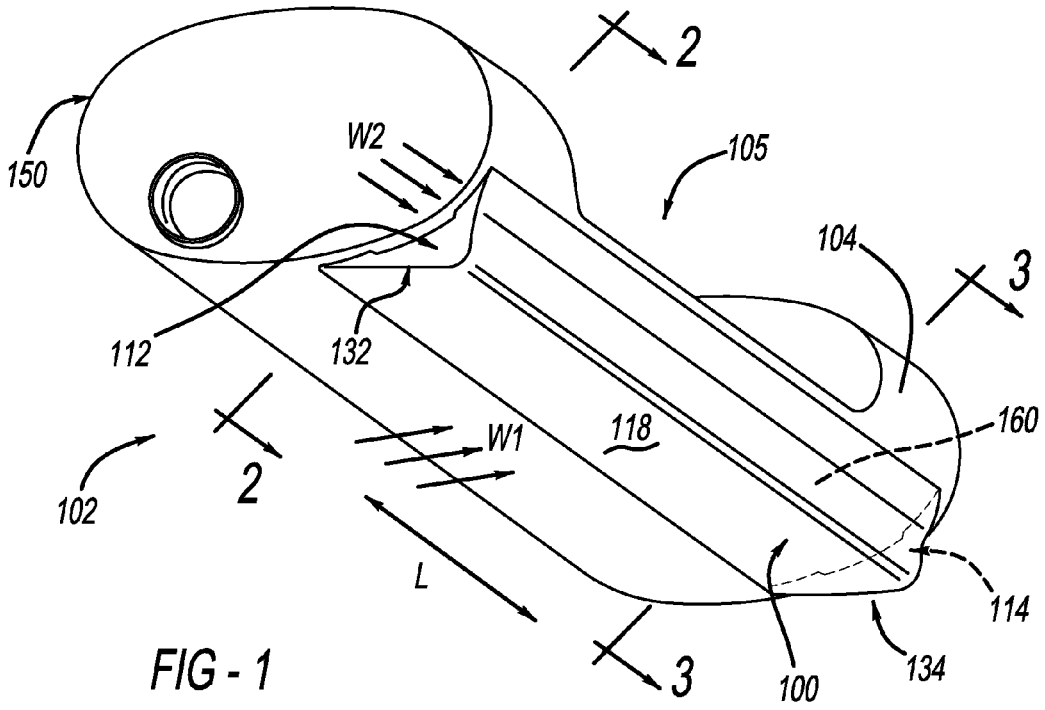
2
150
W2
105
104
3
112
132
160
118
W1
102
2
L
114
3
100
134

FIG - 1

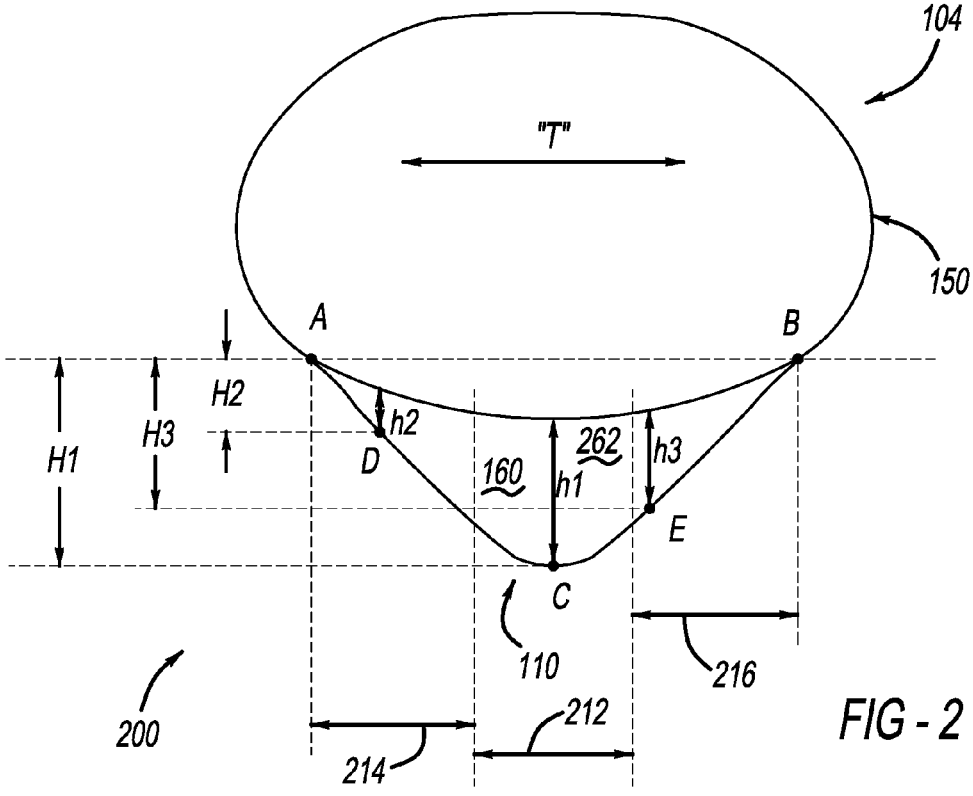
104
"T"
150
A
B
H2
H3
H1
h2
D
160
262
h1
h3
E
C
110
216
200
212
214

FIG - 2

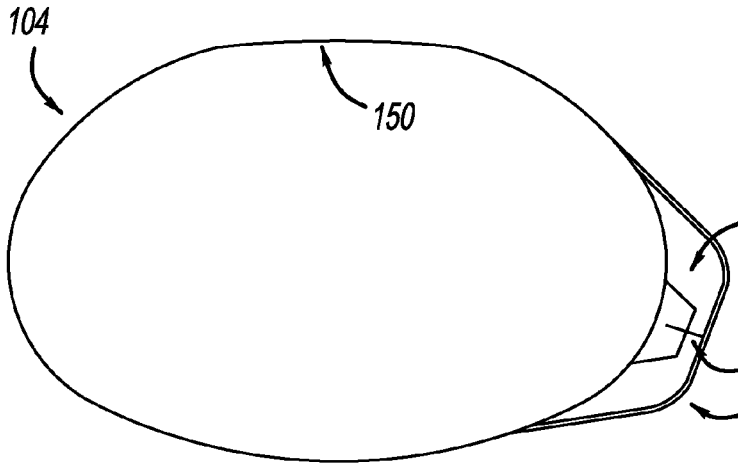


FIG - 3A

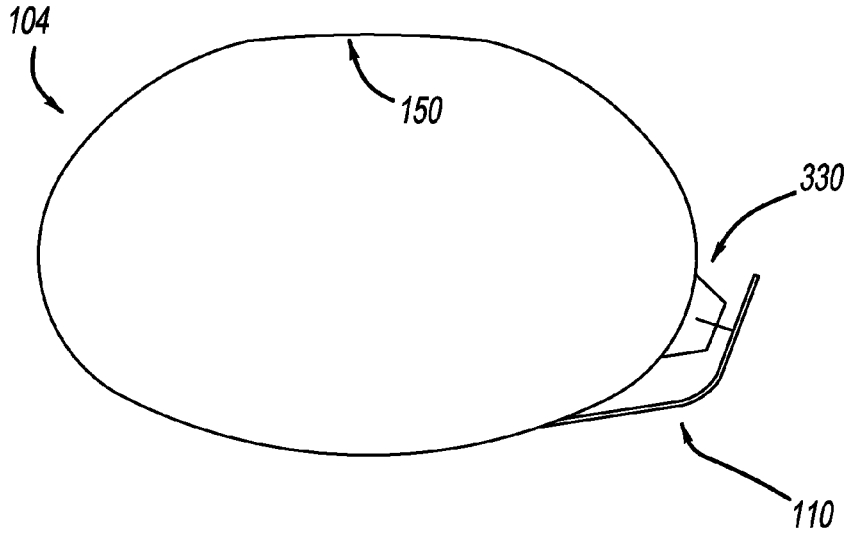


FIG - 3B

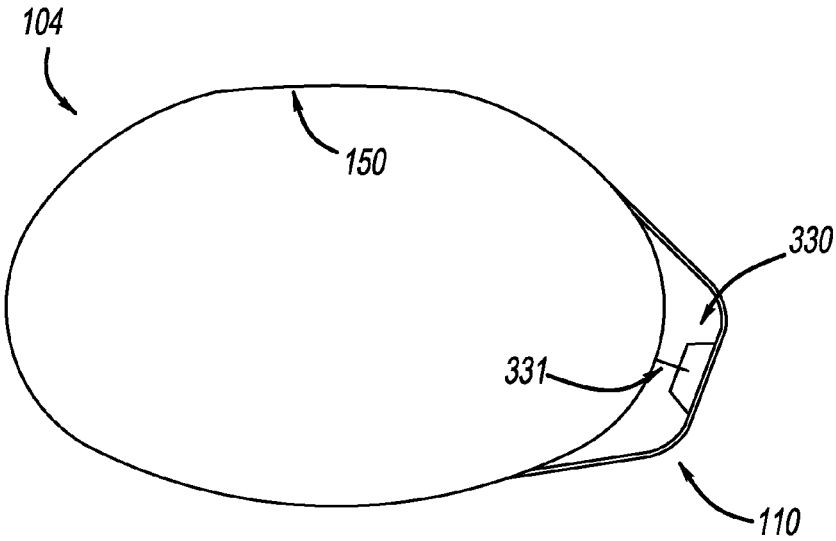


FIG - 3C

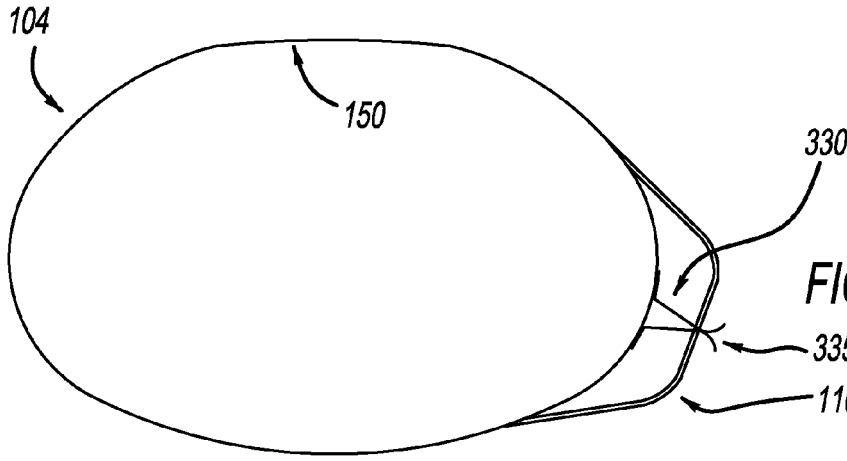


FIG - 3D

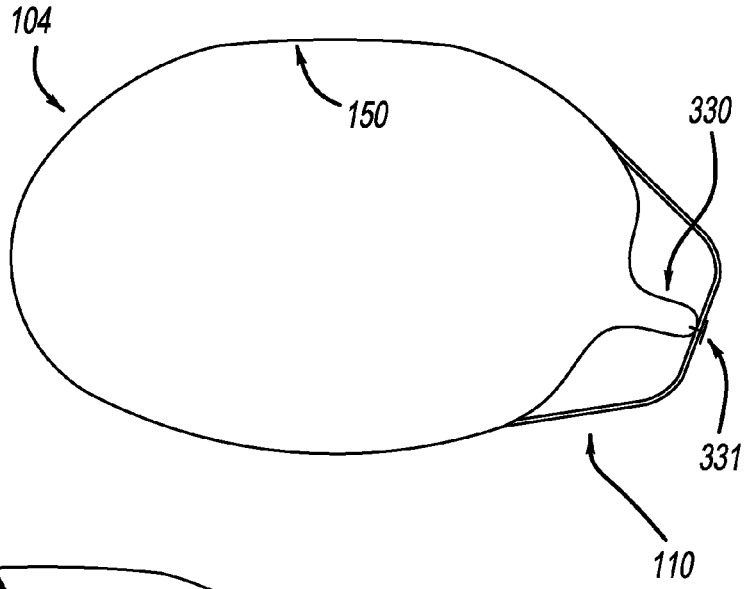


FIG - 3E

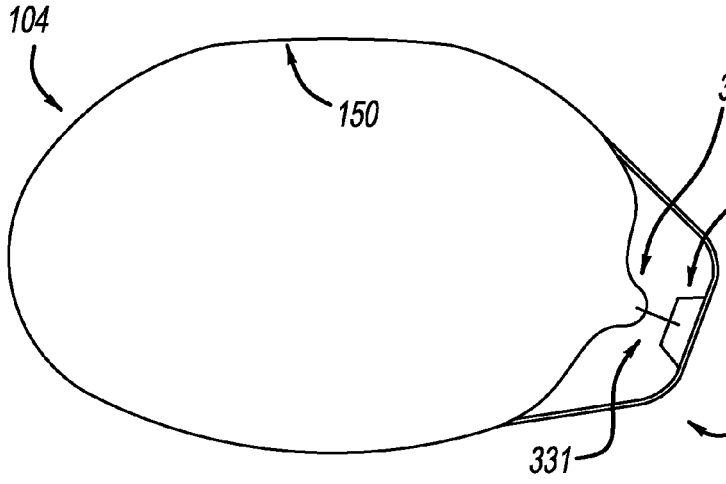


FIG - 3F

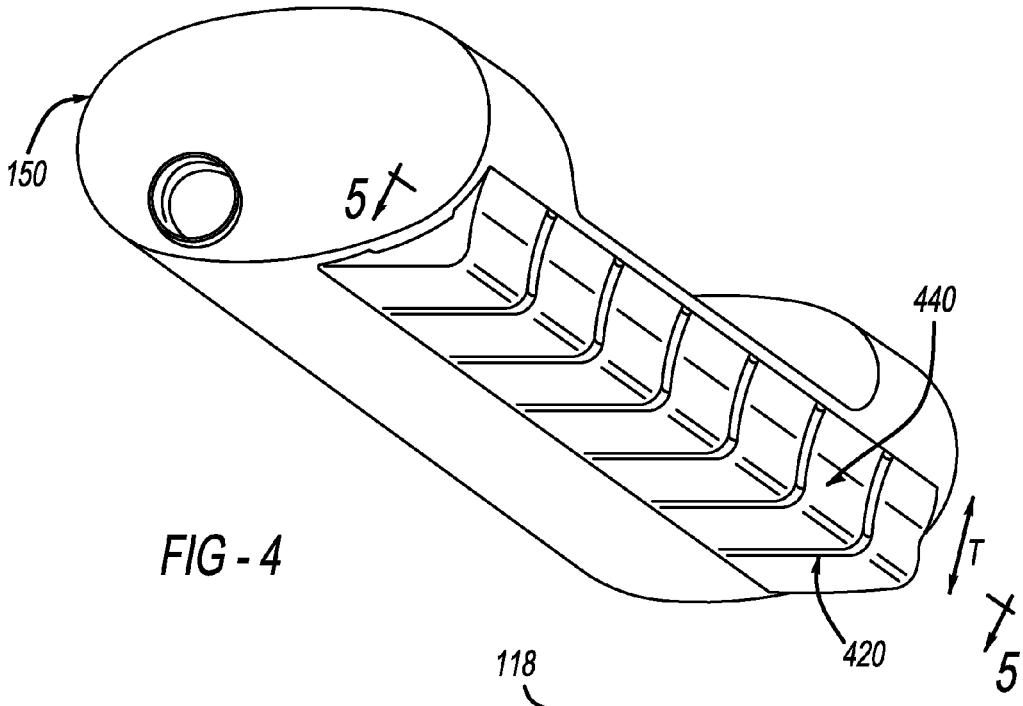


FIG - 4

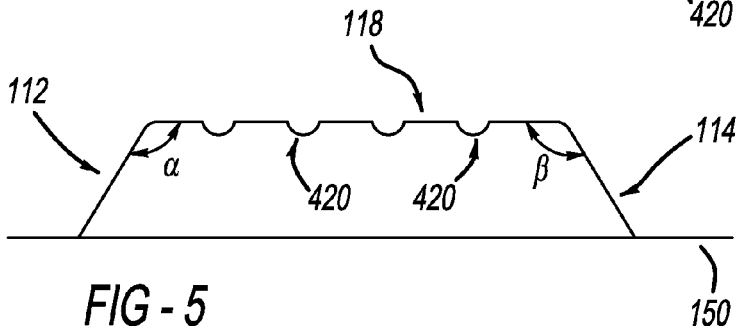


FIG - 5

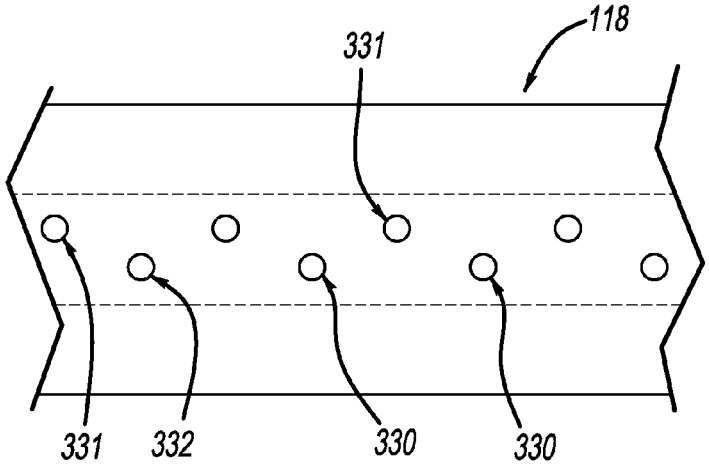


FIG - 6

# MUFFLER SHIELD AND MUFFLER ASSEMBLY EMPLOYING THE SAME

## TECHNICAL FIELD

The disclosed inventive concept relates generally to a muffler shield and a muffler assembly employing the same.

## BACKGROUND

Vehicle exhaust systems often include various exhaust components for treating exhaust gases. A typical exhaust system includes an exhaust pipe directing exhaust gases from an internal combustion engine to a muffler, and a tail pipe guiding the exhaust gases from the muffler to atmospheric air. In addition to guiding exhaust gases, the muffler is also designed to reduce operational noises associated with the engine and exhaust system.

Although functionally useful as indicated herein above, mufflers are often positioned underneath the vehicle body for certain structural and/or mechanical considerations. Because of its under-body position, mufflers may encounter aerodynamic resistance due to wind and speed when the vehicle is in motion.

## SUMMARY

In one or more embodiments, the present invention provides a muffler shield including a shield body extending in a longitudinal direction and defining a middle portion positioned between first and second side portions along a transverse direction, a cross-section of the middle portion and at least one of the first and second side portions respectively defining a middle profile and a side profile shorter than the middle profile.

In another or more embodiments, the present invention provides a muffler assembly, including a muffler extending in a longitudinal direction, and a muffler shield supported on the muffler and defining a middle portion positioned between first and second side portions along a transverse direction, a cross-section of the middle portion and of at least one of the first and second side portions respectively defining a middle profile and a side profile shorter than the middle profile.

In yet another or more embodiments, the present invention further provides a muffler assembly, including a muffler including an exterior surface, a muffler shield supported on the exterior surface of the muffler and extending in a longitudinal direction, the muffler shield defining a middle portion positioned between first and second side portions along a transverse direction, the middle and first and second side portions defining a middle profile, a first and second side profiled relative to exterior surface of the muffler, the middle profile being greater than at least one of the first and second side profiles.

The above advantages and other advantages and features will be readily apparent from the following detailed description of embodiments when taken in connection with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of embodiments of this invention, reference should now be made to the embodiments illustrated in greater detail in the accompanying drawings and described below by way of examples wherein:



FIG. **1** illustratively depicts a perspective view of a muffler assembly in one or more embodiments;

FIG. **2** illustratively depicts a cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **3**A illustratively depicts another cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **3**B illustratively depicts yet another cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **3**C illustratively depicts yet another cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **3**D illustratively depicts yet another cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **3**E illustratively depicts yet another cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **3**F illustratively depicts yet another cross-sectional view of the muffler assembly referenced in FIG. **1**;

FIG. **4** illustratively depicts a perspective view of a variation to the muffler assembly referenced in FIG. **1**;

FIG. **5** illustratively depicts an alternative cross-sectional view of the muffler assembly referenced in FIG. **1** or FIG. **4**; and

FIG. **6** illustratively depicts a top-down view of the muffler assembly referenced in FIG. **1** or FIG. **4**.

## DETAILED DESCRIPTION OF ONE OR MORE EMBODIMENTS

As referenced in the FIG. **1** through FIG. **3**F, the same reference numerals are used to refer to the same components. In the following description, various operating parameters and components are described for different constructed embodiments. These specific parameters and components are included as examples and are not meant to be limiting.

As is detailed herein elsewhere, the present invention in one or more embodiments is believed to be advantageous in being reflective of a discovery on the significance of an air gap between a muffler and a shield thereupon and on the benefit of reducing aerodynamic turbulence associated with the air gap. In particular, the aerodynamic performance is believed to be enhanced when air flow turbulence is reduced at locations where the shield comes to close interaction or contact with the muffler. More particularly, the reduction in air flow turbulence is believed to be realized when such locations are substantially free or entirely free of mechanical connectors, with non-limiting examples thereof including nails, nuts, bolts and threaded fasteners in any shape or form.

In one or more embodiments, and as illustratively depicted in FIG. **1** in view of FIG. **2**, a muffler assembly generally shown at **102** includes a muffler **104** and a muffler shield **100** attached to the muffler **104**. The muffler shield **100** includes a shield body **118** extending in a longitudinal direction "L," which in turn includes a middle portion **212** positioned between first and second side portions **214**, **216** along a transverse direction "T," a cross-section of the middle portion **212** and at least one of the first and second side portions **214**, **216** respectively defining a middle profile "H**1**" and a side profile "H**2**" or "H**3**" shorter than the middle profile "H**1**."

Further in view of FIG. **2**, the middle profile "H**1**" is defined as a linear vertical distance of point "C" on the shield body **118** at cross-section **200** away from line "AB", where the line "AB" is in turn defined by two end points "A" and "B" of the shield body **118** at cross-section **200**. In certain particular embodiments, one or both of the points "A" and "B" are where the shield body **118** comes to contact the muffler **104** at the cross-section **200**.

Further in view of FIG. **2**, the first side profile "H**2**" is defined as a linear vertical distance of point "D" on the shield body **118** at the cross-section **200** away from the line "AB." The point "D" may be any point positioned between the point "A" of the first side portion **214** and the point "C" of the middle portion **212** at the cross-section **200**.

Further in view of FIG. **2**, the second side profile "H**3**" is defined as a linear vertical distance of point "E" on the shield body **118** at cross-section **200** away from the line "AB." The point "E" may be any point positioned between the point "B" of the first side portion **214** and the point "C" of the middle portion **212** at the cross-section **200**.

Referring back to FIG. **2**, the middle portion **212** may be of any suitable dimension along the transverse direction "T" at the cross-section **200** in comparison to the first and second side portions **214**, **216**, as long as the middle portion **212** include the point "C" which is farthest away from the line "AB" in comparison to all other points on the shield body **118** at the cross-section **200**. Accordingly, another cross-section (not shown) of the shield body **118** spaced apart from the cross-section **200** along the longitudinal direction "L" may be spaced apart from the point "C" along the transverse direction "T." Accordingly also, the middle portion **212** includes the point "C" and all its counterparts positioned on all other cross-sections sequentially positioned along the longitudinal direction "L." Accordingly further, the middle portion **212** may be presented with uneven surface shapes due to the fact that the point "C" and all its counterparts may be positioned spaced apart from one and another along the transverse direction "T."

The width of the line "AB" along the transverse direction "T" may be of any suitable values and may vary dependent upon an outer shape of the muffler **104**. In certain particular embodiments, the line "AB" is coordinated in value with the position of the point "C" such that an angle "BCA" defined by line "CA" and line "CB" is greater than 90 degrees and smaller than 180 degrees. This angle design may be beneficial to provide a relatively smoother surface to lead an incoming air flow.

The middle profile "H**1**" is longer than any one of the first and second side profiles "H**2**" and "H**3**;" this is at least because the middle profile "H**1**" defines the point on the shield body **118** at any given cross-section that is farthest away from line "AB." The first and second side profiles "H**2**" and "H**3**" may be the same or different in value.

The profiles "H**1**", "H**2**" and "H**3**" may alternatively be referred to as profiles "h**1**", "h**2**" and "h**3**", with the latter ones defined as linear distances defined between the points "C", "D" and "E" relative to the exterior surface **150** of the muffler **104**, along the same directions by which the profiles "H**1**", "H**2**" and "H**3**" are defined, respectively. In instances where any parts of the exterior surface **150** between points "A" and "B" bend inwardly toward a center of the muffler **104**, the profiles "h**1**", "h**2**" and "h**3**" may each be independently greater than the profiles "H**1**", "H**2**" and "H**3**", respectively.

The shield body **118** may be made of any suitable materials, and may include a metallic material in certain embodiments with non-limiting examples thereof including iron, copper, and a metal oxide of iron or copper. One particular benefit of using a metallic material in forming the shield body **118** may be that the thus formed shield body **118** may be resilient enough to closely align with or directly contact the muffler **104** particularly at the first and/or second side portions **214**, **216**. Accordingly at least a part of the first and/or second side portions and particularly the corresponding leading edge thereof does not necessarily require additional fasteners or connectors due to the presence of the resilient force exerted by the resilient material in combination with the profile differential between "H**1**" as opposed to "H**2**" and/or "H**3**."

Optionally, the closeness of at least a part of the first and/or second side portions **214**, **216** and particularly the corresponding leading edge thereof relative to the muffler **104** may further be enhanced by the use of non-mechanical connectors such as adhesives and heat-assisted soldering.

In certain embodiments, the muffler shield **110** further includes at least one of first and second end covers **112**, **114** as illustratively depicted in FIG. **1**. As illustratively depicted in FIG. **1**, the muffler **104** may include a middle recess **105** to be positioned between the first and second end covers **112**, **114**. The first end cover **112** and/or the second end cover **114** are each positioned to provide a closure respectively at first and second ends **132**, **134** of the shield body **118** to fend off unwanted debris such as dust, rocks, rain or incoming wind which may get trapped between the muffler **104** and the shield body **118** and thereafter cause unnecessary rattle and noise. The first and second end covers **112**, **114** are particularly beneficial due to the unique cross-sectional shape of the shield body **118**, which imparts a relatively more prominent middle elevation as mentioned herein elsewhere and hence relatively higher tendency to catch the unwanted debris in certain driving conditions. With the employment of the first and/or second end covers **112**, **114**, the muffler shield **110** is positioned with relatively reduced rattle creation due to air movement not only in a direction generally shown at "W**1**" but also in a direction generally shown at "W**2**."

In addition, the first and/or the second end covers **112**, **114** may include or be formed of relatively sturdy or rigid material so as to provide additional structural support to the muffler shield **110** and to help prevent the shield body **118** from collapsing down to the exterior surface **150** of the muffler **104**.

Although the presence of the first and/or second end covers **112**, **114** may be beneficial to reduce air-induced and/or mechanical vibration-induced rattle in some instances, the presence of one or both of the first and second end covers **112**, **114** may not be required in others dependent upon a particular shape, design or under-body positioning of the muffler **104** itself.

When employed, the first and second end covers **112**, **114** may each be independently pre-formed and thereafter attached to the shield body **118** to form the muffler shield **110**. Optionally also, the first and/or second end covers **112**, **114** may be formed as integral extension from the shield body **118**.

In certain embodiments, and as illustratively depicted in FIG. **5**, one or both of the first and second end covers **112**, **114** may be positioned relative to the shield body **118** with an angle $\alpha$ and an angle $\beta$, respectively, where at least one of the angles $\alpha$ and $\beta$ is greater than 90 degrees. This configuration may be particularly beneficial for avoiding any unnecessary resistance to an incoming air flow.

In certain embodiments, the first end cover **112** and/or the second end cover **114** may at least partially contact any one of the first side portion **214**, the middle portion **212**, the second side portion **216**, and an exterior surface **150** of the muffler **104**.

In certain embodiments, the muffler shield **110** defines there-within a cavity **160** along with the exterior surface **150** of the muffler **104**. This is beneficial to reduce unnecessary weight of the muffler shield **110** particularly when the muffler shield **110** is for under-body mount as illustratively depicted in FIG. **1**. For the non-limiting consideration of

further reducing air-induced rattle and/or mechanical vibration-induced rattle, a filler (not shown) may be placed in any open spaced allotted within the cavity **160**. The filler is optionally light-weight and relatively heat resistant, and may be of any suitable material, with non-limiting examples thereof including plastic threads, carbon threads, and metallic threads, which tend to possess relatively higher volume-to-weight ratios. When employed, the filler is believed to provide cushion between the relatively rigid construction of the muffler shield **100** relative to the exterior surface **150** of the muffler **104**. In addition, the open spaces or the pores defined within the filler due to the relatively large volume-to-weight ratios further helps absorb or trap air pockets and hence noise.

As mentioned herein elsewhere, one of the considerations in reducing air-induced rattle and/or mechanical vibration-induced rattle is to reduce or eliminate the presence of any mechanical fasteners at the first and/or second side portions **214**, **216**. Accordingly one or more fasteners may be positioned at the middle portion **212** to provide added connective force for the muffler shield **110** to adhere well to the muffler **104**. Because of the elevation of the middle portion **212** relative to the exterior surface **150** of the muffler **104**, the one or more fasteners are designed and positioned to accommodate the elevation while providing the connective force.

As illustratively depicted in FIG. **3**A, which is a cross-section of the muffler assembly **100** referenced in FIG. **1** taken along line **3-3**, where the muffler shield **110** is shown as mounted onto the exterior surface **150** of the muffler **104** by a stand-off connector **330** and a threaded fastener **331** engaged with the stand-off connector **330**. The stand-off connector **330** and the threaded fastener **331** may each of any suitable shape and be formed of any suitable material. One consideration is that the stand-off connector **330**, when working in concert with the threaded fastener **331**, provides a connective force for that the attachment of the muffler shield **110** onto the muffler **104** and concurrently functions as an elevation spacer for maintaining the general configuration of the muffler shield **100**. More than one pair of the stand-off connector **330** and the threaded fastener **331** may be employed along the longitudinal direction "L" and/or along the transverse direction "T" within the middle portion **212**. The stand-off connector **330** may be welded onto or stamped into the exterior surface **150** of the muffler **104**.

FIG. **3**B illustratively depicts a cross-sectional view of a variation to the muffler assembly **102** referenced in FIG. **1**, where at least a part of the second side portion **216** is omitted under certain instances, and where the connector-fastener arrange is similar to the one illustratively depicted in FIG. **3**A. The configuration here may be particularly beneficial in instances due to the weight or the shape of the muffler shield **100**, and/or any particular design of the muffler **104** at hand.

FIG. **3**C illustratively depicts another alternative cross-sectional view of the muffler assembly **102** referenced in FIG. **1** taken along line **3-3**, where the stand-off connector **330** is shown to be positioned onto the middle portion **214** of the muffler shield **110** and the threaded connector **331** is instead connected to the exterior surface **150** of the muffler **104**. Essentially the configuration of the connector-fastener pair shown in FIG. **3**C presents a reverse arrangement relative to what is depicted in FIG. **3**A. For certain considerations, such as the consideration of more effectively utilizing the space available from the cavity **160**, one or more of the connector-fastener pairs shown in FIG. **3**A and one or more of the connector-fastener pairs shown in FIG. **3**C may be concurrently employed in a single muffler assembly **102**.

FIG. **3**D illustratively depicts an alternative cross-sectional view of the muffler assembly **102** referenced in FIG. **1** taken along line **3-3**, where the stand-off connector **330** is used alone without the threaded fastener **331**. As illustratively depicted in FIG. **3**D, the stand-off connector **330** may sit on or through the exterior surface **150** of the muffler **104** and be configured with an end point **335** piercing through and thus be connected to the middle portion **212** of the muffler shield **110**. Once piercing through the middle portion **212**, the end point **335** may be bent down towards an exterior surface of the middle portion **212** to provided added connection. Similar to what is mentioned in relation to FIG. **3**A, the stand-off connector **330** may be attached to the muffler **104** via any suitable methods involving the use of adhesives, screws or heat-assisted welding. From the view point of only one piece of connector may be needed for attachment, relatively enhanced cost and labor efficiency may be provided to the configuration shown in FIG. **3**D.

FIG. **3**E illustratively depicts another alternative cross-sectional view of the muffler assembly **102** referenced in FIG. **1** taken along line **3-3**, where the stand-off connector **330** is shown to be an integral part of the muffler **104** or the exterior surface **150** thereof. Similar to what is depicted in FIG. **3**A, one or more threaded fasteners **331** may be used to secure the attachment between the stand-off connector **330** and hence the muffler **104** to the muffler shield **100**. This configuration may be particularly beneficial where the muffler **104** is of certain material or configuration where attachment thereto of one of more of the stand-off connectors **330** may be feasible in certain instances.

FIG. **3**F illustratively depicts an alternative cross-sectional view of the muffler assembly **102** referenced in FIG. **1** taken along line **3-3**, which combines the configurations shown in FIG. **3**C and FIG. **3**E. This arrangement of the stand-off connector **330** coupled with a second stand-off connector **332** and the threaded fastener **331** is believed to advantageous in supporting the attachment of the muffler shield **100** to the muffler **104** wherein the middle profile "H1" of the middle portion **212** of the muffler shield **100** may be of a particularly greater value and where a single stand-off connector may not be sturdy enough or be of big enough in profile value to provide the support.

Various configurations of the stand-of connector illustratively depicted in FIG. **3**A through FIG. **3**F may be employed individually or in any suitable combination to attach the muffler shield **110** to the muffler **104**. In addition, and as mentioned herein elsewhere, one or more of the connectors illustratively depicted in FIG. **3**A through FIG. **3**F may be arranged in or on the middle portion **212** of the muffler shield **100** along the longitudinal direction "L" and/or the transverse direction "T." FIG. **6** illustratively depicts a top-down view of the shield body **118** when a number of the threaded fasteners **331** and/or a number of the stand-of connectors **330** or **332** are employed in or on the middle portion **212** of the shield body **118**.

Optionally, and as illustratively depicted in FIG. **4**, one or more grooves **420** may be formed on an exterior surface **440** of the muffler shield **100**. The grooves **420** are oriented to lead an incoming air flow so as to further reduce air-induced rattle or turbulence, and/or mechanical vibration-induced rattle. The grooves **420** may be spaced apart from each other with any suitable distance in between. The grooves **420** may be formed as an integral part of the muffler shield **100** and the shield body **118** in particular. Each of the grooves **420** may span at least a part of the width of the shield body **118** along the transverse direction "T."

In one or more embodiments, the present invention as set forth herein is believed to have overcome certain challenges associated with air-induced rattle and/or mechanical vibration-induced rattle in a muffler shield. However, one skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims that various changes, modifications and variations can be made therein without departing from the true spirit and fair scope of the invention as defined by the following claims.

What is claimed is:

**1**. A muffler assembly comprising:

a muffler with a longitudinal axis thereof extending along a vehicle-width direction when installed onto a vehicle; and

a shield supported on an exterior surface of the muffler and defining a middle portion positioned between first and second side portions along a vehicle-length direction, a cross-section of the middle portion and of at least one of the first and second side portions respectively defining a middle profile and a side profile shorter than the middle profile, wherein the middle profile is a middle linear distance of a middle outer surface of the middle portion at the cross-section away from the exterior surface of the muffler along a direction transverse to the vehicle-length direction, and wherein the side profile is a side linear distance of a side outer surface of the at least one of the first and second side portions at the cross-section away from the exterior surface of the muffler along the direction transverse to the vehicle-length direction, wherein the second side portion is more posteriorly positioned than the first side portion as installed onto the vehicle, and wherein the second side portion is with a greater gap distance away from the exterior surface of the muffler than the first side portion.

**2**. The muffler assembly of claim **1**, further comprising a first end cover positioned between the shield body and the exterior surface of the muffler, the first end cover contacting at least one of the middle portion and the first and second side portions of the shield body.

**3**. The muffler assembly of claim **2**, further comprising a second end cover positioned between the shield body and the exterior surface of the muffler, the second end cover contacting at least one of the middle portion and the first and second side portions of the shield body.

**4**. The muffler assembly of claim **3**, wherein the muffler includes a middle recess positioned between the first and second end covers along the vehicle-width direction.

**5**. The muffler assembly of claim **1**, further comprising a first stand-off connector and a second stand-off connector for connecting the shield body to the muffler, wherein the second stand-off connector is spaced apart from the first stand-off connector along the vehicle-width direction.

**6**. The muffler assembly of claim **1**, wherein the shield is elongated with a length extending along the vehicle-width direction and a width extending along the vehicle-length direction, the width is shorter than the length, when the shield and the muffler are installed onto the vehicle.

**7**. The muffler assembly of claim **1**, wherein the shield further includes an elongated groove extending along the vehicle-length direction.

**8**. The muffler assembly of claim **1**, wherein the shield is positioned at least partially underneath the muffler when the shield and the muffler are installed onto the vehicle.

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